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Assessment of Economic Viability of Different Agroforestry Systems in Giri Catchment, Himachal Pradesh

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Abstract

In Himachal Pradesh, 80 percent of its total population lives in villages. Their economy is depends on agriculture, horticulture and animal husbandry. The practice of pure agriculture in HP is sufficient for the inhabitants to sustain only their food requirements but, for other needs peoples are forced to exploit forests. The present investigation was carried out in Giri catchment in located between 30° 33′ 48′′ and 31° 16′ 08′′ N latitude and 77° 02′ 32′′ to 77° 38′ 22′′ E longitude in Himachal Pradesh. The net returns from agroforestry systems decreased, though statistically insignificant, in the order agrisilviculture system (277415.00 Rs. ha^{-1} yr^{-1}) > agrisilvihorticulture system (270747.00 ₹ ha^{-1} yr^{-1}) > agrihortisilviculture (269033.00 ₹ ha^{-1} yr^{-1}) > agrihortisilviculture (225880.30 ₹ ha^{-1} yr^{-1}) systems. The benefit-cost ratio in silvipasture system was significantly higher (3.34) than all other systems and it decreased in the order: S_6 (2.53) > S_4 (2.38) > S_3 (2.17) > S_1 (2.10) > S_1 (1.87).

Keywords: Agroforestry system, Himachal Pradesh, net return, benefit-cost ratio

Agriculture is the main occupation of about 80 percent of the people in Himachal Pradesh of India. The agricultural production in the Himachal Pradesh is leading to the massive consumption of forest energy, and yet the level of agricultural production is insufficient to meet the human needs. The mounting population subsequently requires higher amounts of forest products and even today the production in forestry sector is not enough to meet the existing demands, which ultimately creates intense pressure on the reserve forest. In the present context therefore, the agroforestry is the only viable alternative, through which the pressure on existing forests can be minimized. In addition to this, it can also play a significant role in the conservation of natural resources of Giri Catchment of North-west Himalaya. Productivity studies often ends up with generating data about how much carbon is stored in the living biomass - roots, trunks, and leaves of plants - after tallying up carbon gains through photosynthesis and carbon losses through respiration. Forests are important for carbon sequestration besides playing very important role in the global carbon cycle (IPCC, 2001). Agroforestry has recognized itself as one of the most productive and protective land management systems, helping the farming systems in North-west Himalaya in sustainable basis. But still there is a paucity of information regarding positive or negative impacts on each land unit system from farmers' viewpoints. This paper discusses the agroforestry systems as a sustainable land production systems, identify the suitable agroforestry systems which have monetary returns and estimate the cost-benefit analysis for economic sustainability in the in Giri catchment, Himachal Pradesh.

Database and Methodology

The present study was carried out in Giri catchment, a component of Giri river in Himachal Pradesh, located between 30° 33′ 48′′ and 31° 16′ 08′′ N latitude and 77° 02′ 32′′ to 77° 38′ 22′′ E longitude (Fig 1). It has an area of about 2389 km^2 (Rao *et al.* 1989). Catchment is distributed in Shimla, Sirmour and Solan districts of Himachal Pradesh that includes 135 sub-watersheds.

Out of the 135 sub-watersheds in Giri catchment, 13 sub-watersheds viz., SW_1 to SW_{13} were randomly

selected to study socio-economic status and vegetation composition in them. Each selected sub-watershed was delineated into three elevations for further investigations viz., elevation E_1 (900-1300 m), E_2 (1301-1700 m) and E_3 (1701 - 2100 m). Thus, the total numbers of experimental sites (treatments) available from which the observations were taken was:

Number of sub-watersheds	:	13
Number of elevations in each sub-watershed	:	03
Total number of experimental sites (treatments)	:	13 × 3 = 39

Fig. 1. Location of the Giri catchment and sub-watersheds in it

At every elevation in the selected sub-watersheds, total number of villages were counted. The number of villages at any elevation did not exceed 10. Hence, one representative village was selected at every elevation in the selected sub-watersheds for socio-economic analysis. The number of households in a village fluctuated from 51 to 53. Out of the total households, 5 household heads were selected for personal interview through pre-tested schedule to gather information.

The land uses on which the agrarian people of the catchment are pre-dominantly dependent were considered for further vegetation analysis. Thus, Cultivable, Chir pine based forests and grasslands land uses were selected for study. Using above mentioned frame-work for identifying agroforestry systems, four distinct types of agroforestry systems existing in the catchment were taken for study in which different system units were identified. Thus, in all, six systems were explored for vegetation analysis at each elevation in selected sub-watersheds, which are (a) S_1 = Agri-silviculture system (AS); (b) S_2 = Agri-horticulture system (AH); (c) S_3 = Agrihortisilviculture system (AHS); (d) S_4

Table 1: Gross return (₹ $ha^{-1}yr^{-1}$) from systems in Giri catchment of HP

Systems (S)	Elevation			Mean (S)
	E_1 (900 -1300 m)	E_2 (1301 - 1700 m)	E_3 (1701 - 2100 m)	
S_1	3,80,814.00	3,30,788.30	3,46,197.70	3,52,600.00
S_2	2,93,563.30	1,99,991.70	5,40,110.00	3,44,555.00
S_3	1,90,291.70	2,85,825.00	3,39,532.70	2,71,883.10
S_4	2,46,940.80	3,34,671.70	4,05,281.70	3,28,964.70
S_5	20,531.60	24,691.60	21,908.33	22,377.18
S_6	15,750.00	15,525.00	14,175.00	15,150.00
Mean (E)	1,91,315.20	1,98,582.20	2,77,867.60	

	C.D.	SEm ±				
Elevation (E)	41,707.00	14,449.00	S_1	Agrisilviculture	S_4	Agrisilvihorticulture
System (S)	58,983.00	20,435.00	S_2	Agrihorticulture	S_5	Silvipasture
Interaction E X S	102,162.00	35,394.00	S_3	Agrihortisilviculture	S_6	Grassland

Table 2: Total expenses (₹ $ha^{-1}yr^{-1}$) incurred in systems in Giri catchment of HP

Systems (S)	Elevation			Mean (S)
	E_1 (900 -1300 m)	E_2 (1301 - 1700 m)	E_3 (1701 - 2100 m)	
S_1	1,80,802.10	1,47,126.90	1,76,124.90	1,68,017.90
S_2	1,71,935.40	1,30,746.40	2,21,391.00	1,74,690.90
S_3	99,173.19	1,30,360.60	1,41,902.90	1,23,812.30
S_4	128660.00	139836.60	142303.90	136933.50
S_5	6466.67	7166.67	6466.67	6700.00
S_6	6000.00	6000.00	6000.00	6000.00
Mean (E)	98,839.57	93,539.54	1,15,698.20	

	C.D.	SE(m) ±				
Elevation (E)	14,465.00	5,011.00	S_1	Agrisilviculture	S_4	Agrisilvihorticulture
System (S)	20,457.00	7,087.00	S_2	Agrihorticulture	S_5	Silvipasture
Interaction E X S	35,434.00	12,276.00	S_3	Agrihortisilviculture	S_6	Grassland

= Agrisilvihorticulture system (ASH); (e) S_5 = Silvipasture system (SP); (f) S_6 = Grassland (GS).

The economic yield in different agroforestry systems was calculated by determining, (i) Production cost (Input); (ii) Gross return; (iii) Net Return. The data obtained were subjected to statistical analysis as per the procedure suggested by Gomez and Gomez (1984). Wherever, the effects exhibited a significance of 5 per cent level of probability, the critical difference (CD) was calculated. Analysis was carried out by using statistical package "*STATISTICS*". Information on agroforestry interventions in Giri catchment on the above discussed parameters is not adequate. Hence, the present investigation was aimed at Assessment of economic viability of different agroforestry systems in Giri catchment, Himachal Pradesh.

Results and Discussion

The mean gross returns from agrisilviculture (₹ 352600.00 ha^{-1} yr^{-1}), agrihorticulture (₹ 344555.00 ha^{-1} yr^{-1}) and agri-silvi-horticulture (328964.00 ₹ $ha^{-1}yr^{-1}$) systems were at par but significantly higher than agrihortisilviculture (S_3) (₹ 271883.00 $ha^{-1}yr^{-1}$). Also, the gross return from silvipasture (₹ 22,377.00 $ha^{-1}yr^{-1}$) and grassland (₹ 15150.00 ha^{-1} yr^{-1}) were at par, but significantly low than the other agroforestry systems (Table 1). However, it was found that gross returns from the systems decreased in the order: $S_1 > S_2 > S_4 > S_3 > S_5 > S_6$. It was recorded that gross return from silvipasture was less than 8% and from grassland less than 5% of what we get from agri-horti-silviculture system the least remunerative amongst agroforestry systems i.e., S_1, S_2, S_3 and S_4. Gross returns from systems was significantly higher at elevation E_3 but was at par on elevations E_1 and E_2. The interaction between elevations and systems showed that maximum (₹ 540110.00 $ha^{-1}yr^{-1}$) gross return was obtained from agrihorticulture system (S_2E_3) at elevation E_3 and minimum gross return (₹ 14,175.00 $ha^{-1}yr^{-1}$) was obtained from grassland (S_6E_3) at elevation E_3.

Data presented in Table 2 revealed that mean maximum total expenses incurred in agri-horticulture system (₹ 174690.00 ha^{-1} yr^{-1}) were statistically at par with agri-silvi-culture system (₹ 168017.00 $ha^{-1}yr^{-1}$) but significantly higher than other systems. Minimum expenditure incurred in grassland (₹ 6000 $ha^{-1}yr^{-1}$). The

Table 3: Net return (₹ ha^{-1} yr^{-1}) from systems at different elevations in Giri catchment of HP

Systems (S)	Elevation			Mean (S)
	E_1 (900 -1300 m)	E_2 (1301 - 1700 m)	E_3 (1701 - 2100 m)	
S_1	2,81,576.90	2,69,458.80	2,81,211.70	2,77,415.80
S_2	2,17,976.90	1,39,439.80	4,49,682.40	2,69,033.00
S_3	1,52,431.80	2,54,152.50	2,71,056.60	2,25,880.30
S_4	1,86,308.80	2,83,654.70	3,42,278.40	2,70,747.30
S_5	18,931.60	21,191.60	20,308.33	20,143.84
S_6	13,750.00	13,525.00	12,175.00	13,150.00
Mean (E)	1,45,162.70	1,63,570.40	2,29,452.10	

	C.D.	SEm ±
Elevation (E)	48,972.00	16,966.00
System (S)	69,257.00	23,994.00
Interaction E X S	119,957.00	41,559.00

S_1 Agrisilviculture; S_2 Agrihorticulture; S_3 Agrihortisilviculture; S_4 Agrisilvihorticulture; S_5 Silvipasture; S_6 Grassland

Table 4: Benefit-cost ratio of vegetation systems at different elevations in Giri catchment of HP

Systems (S)	Elevation			Mean (S)
	E_1 (900 -1300 m)	E_2 (1301 - 1700 m)	E_3 (1701 - 2100 m)	
S_1	2.08	2.24	1.97	2.10
S_2	1.70	1.52	2.40	1.87
S_3	1.93	2.16	2.43	2.17
S_4	1.93	2.40	2.83	2.38
S_5	3.19	3.45	3.38	3.34
S_6	2.63	2.59	2.36	2.53
Mean (E)	2.24	2.39	2.56	

	C.D.	SEm ±
Elevation (E)	0.15	0.05
System (S)	0.21	0.07
Interaction EXS	0.38	0.13

S_1 Agrisilviculture; S_2 Agrihorticulture; S_3 Agrihortisilviculture; S_4 Agrisilvihorticulture; S_5 Silvipasture; S_6 Grassland

f expenditure incurred in systems at different elevations revealed that maximum total expenses were done in systems at elevation E_3 (₹ 115698.00 $ha^{-1}yr^{-1}$) which was significantly higher than the expenses done at elevations E_1 and E_2.

The interaction between systems and elevations revealed that highest cost (₹ 221391.00 $ha^{-1}yr^{-1}$) was incurred in agri-horticulture system (S_2) at elevation E_3. It was significantly higher than all other interactions. Minimum (₹ 6000.00 $ha^{-1}yr^{-1}$) cost was recorded in grasslands at all the three elevations.

A perusal of data in Table 3 revealed that mean maximum net return was obtained from agri-silvi-culture system (₹ 277415.00 ha^{-1} yr^{-1}) which was statistically at par with agrisilvihorticulture (270747.00 ₹ ha^{-1} yr^{-1}) and agrihortisilviculture (₹ 269033.00 ha^{-1} yr^{-1}) systems. Minimum (₹ 13150.00 ha^{-1} yr^{-1}) net return was obtained from grassland system it was significantly lower than all other systems except silvipasture system (₹ 20143.00 $ha^{-1}yr^{-1}$). The variation of net return obtained from systems at different elevations revealed that maximum net return was obtained at elevation E3 (₹ 229452.00 $ha^{-1}yr^{-1}$) which was significantly higher than the net return obtained at elevations E_1 and E_2. The interaction of elevations and systems exhibited that maximum net return was obtained from agri-horticulture system at elevation E_3 (₹ 449682.00 ha^{-1} yr^{-1}). However, it was statistically at par with agri-silvi-horticulture at elevation E_3 (₹ 342278.00 ha^{-1} yr^{-1}). Minimum net return of was obtained from grassland (S_6) at elevation E_3 (₹ 12175.00 ha^{-1} yr^{-1}).

The Benefit-Cost ratio (Table 4) in silvipasture system was significantly higher (3.34) than all other systems. However, it was found that mean benefit-cost ratio of the systems decreased in the order: $S_6 > S_5 > S_4 > S_3 > S_1$. Mean minimum benefit-cost ratio (1.87) was recorded in agri-horticulture system, which was significantly lower than all other systems. The variation of mean benefit-cost ratio recorded in systems at different elevations revealed that mean maximum benefit-cost ratio were recorded at elevation E_3 (2.56) which was significantly higher than the Benefit- cost ratio recorded at elevations E_1 (2.24) and E_2 (2.56).

The interaction of systems and elevations exhibited that maximum benefit-cost ratio (3.45) was recorded in silvipasture (S_5) at elevation E_2 and it was statistically at par with silvipasture (S_5) at elevation E_3 (3.38) and silvipasture (S_5) at elevation E_1 (3.49). The benefit-cost ratio of silvipasture system at all three elevations was significantly higher than other interactions.

Bio-economic appraisals of different systems of valley and mountainous areas of Kullu district, north-western Himalayas studied by Rajpoot (2010) and reported 10.23 ₹ lakh ha^{-1} yr^{-1} net profit from fruit orchard + vegetable-vegetable system in valley whereas, 9.69 ₹ Lakh ha^{-1} yr^{-1} from agri-horticulture in mountainous area. These systems from the respective areas also offer maximum total benefits (net profit including carbon credits). Rajput (2010) reported benefit-cost ratio of 2.94 for agri-horticulture in Kullu valley of Himachal Pradesh, whereas benefit cost ratio 1.99 to 2.34 for agri-silvi-horticulture systems in Solan (HP) reported by Verma *et al.* (2002). A range of benefit cost ratio from 1.87-5.7 have been reported by Kumar *et al.* (2002) for hortipastoral systems at Jhansi; Bhatt and Mishra (2003) for Assam lemon and Guava based agroforestry systems in Meghalaya and Sharma (2007) for cardamom based in Sikkim.

Conclusion

The gross and net returns were higher from agroforestry systems as compared to traditional chir pine based silvipasture and grasslands. It is pertinent to mention here that, in tree based agroforestry systems, the economic value of trees was calculated for fuel wood only. Among agroforestry systems economic returns were governed by the arrangement of components, their management, yield and market value. The returns (gross and net) were highest from agri-silvi-culture system because vegetable crops like tomato, capsicum, garlic and beans are cultivated in large area that fetch more capital to the farmers from market. The returns from agri-horticulture, agrihortisilviculture and agri-silvi-horticulture were slightly less, though statistically non-significant, than agri-silvi-culture because the cash crops mentioned above are grown in lesser areas in these systems. Very low returns from chir pine based silvipasture and grasslands were due to low market value of fuelwood and fodder taken from them.

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